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August 18, 2003
In reply refer to 2003RC3113

BOEING

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Subject: Perchlorate Characterization Work Plan
Santa Susana Field Laboratory
Ventura County, CA

Dear Mr. Pappas:

Pursuant to your letter dated June 23, 2003, The Boeing Company (Boeing) hereby submits the requested work plan dated August 18, 2003, prepared by Montgomery Watson Harza. This work plan outlines the scope of work proposed by Boeing to address the Department of Toxic Substance Control Division concern for potential off-site migration of perchlorate from the SSFL.

If you have any questions, please contact me at (818) 586-2577 or Art Lenox at (818) 586-5695.

Sincerely,

Steve Lafflam
Division Director
Safety, Health & Environmental Affairs

AL:po
Enclosure

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BOEING

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DRAFT - Under Review by DTSC

PERCHLORATE CHARACTERIZATION WORK PLAN
SANTA SUSANA FIELD LABORATORY
VENTURA COUNTY, CALIFORNIA

Prepared For:

THE BOEING COMPANY
Rocketdyne Propulsion and Power

Prepared By:

MWH
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August 2003

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MWH

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Boeing	The Boeing Company
CAL-EPA	California Environmental Protection Agency
COCs	Constituents of Concern
CMI	Corrective Measures Implementation
CMS	Corrective Measures Study
DTSC	Department of Toxic Substances Control
EPA	Environmental Protection Agency
ft/ft	feet per foot
FSDF	Former Sodium Disposal Facility
LOX	liquid oxygen
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
NPDES	National Pollution Discharge Elimination System
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RWQCB	Regional Water Quality Control Board
SAIC	Science Applications International Corporation
SSFL	Santa Susana Field Laboratory
TCE	trichloroethene
TDS	total dissolved solids
TTF	Thermal Treatment Facility
USGS	United States Geologic Survey
VOC	volatile organic compound

1.0 INTRODUCTION

This Resource Conservation and Recovery Act (RCRA) facility investigation (RFI) work plan presents characterization activities to evaluate the potential for off-site migration of perchlorate from the Santa Susana Field Laboratory (SSFL). This work plan has been prepared by MWH on behalf of The Boeing Company (Boeing) in response to a California Environmental Protection Agency (Cal-EPA), Department of Toxic Substances Control (DTSC) requirement specified in a letter dated June 23, 2003 (DTSC, 2003, Appendix A). In this letter, DTSC has requested the submittal of an RFI work plan describing measures to be taken to investigate the potential migration of perchlorate contamination from the SSFL to off-site areas such as the Brandeis-Bardin Institute property. In particular, this RFI work plan presents characterization activities to confirm that perchlorate is absent in groundwater discharging from Bathtub Well #1 and to evaluate the nature and extent of potential perchlorate releases to the Northern Drainage of the SSFL from the Building 359 RFI site. Bathtub Well #1 is an uncapped, flowing artesian groundwater well located on property owned by the Brandeis-Bardin Institute and is located approximately 4,700 feet north of the northern SSFL property boundary (Figure 1). This well is referred to as a "Bathtub Well" because groundwater flowing from the well discharges into a partially buried bathtub. This well was previously labeled by Boeing as OS-9 during the 1980s and will be referenced as such throughout the remainder of this work plan.

Perchlorate occurrence at the SSFL has been previously described in a detailed, comprehensive report entitled *Perchlorate Source Evaluation and Technical Report, Santa Susana Field Laboratory, Ventura County, California* (Perchlorate Report, MWH, 2003a). The characterization of perchlorate in the two areas where it was primarily used at the SSFL was updated in the *Happy Valley Interim Measures Work Plan Addendum, Happy Valley and Building 359 Areas of Concern, Santa Susana Field Laboratory, Ventura County, California* (Interim Measures Work Plan, MWH, 2003c). The Interim Measures Work Plan presented additional perchlorate sampling data collected at the Happy Valley and Building 359 RFI sites between February and May 2003. Additional environmental media have been sampled and analyzed for perchlorate both at the SSFL and in off-site areas since the submittal of the report and work plan mentioned above. A summary of these additional data will be presented in

Section 2.2 of this work plan and a full presentation of all of the data will be provided in an addendum to the Perchlorate Report that will be issued in the fourth quarter of 2003.

1.1 SSFL FACILITY INFORMATION

The SSFL is located approximately 29 miles northwest of downtown Los Angeles, California, in the southeast corner of Ventura County. The SSFL occupies approximately 2,850 acres of hilly terrain with approximately 700 feet of topographic relief near the crest of the Simi Hills. The SSFL has been active since 1948 and is divided into four administrative areas (Areas I, II, III, and IV), with undeveloped land along the northern and southern boundaries (Figure 1).

The primary site activities at the SSFL since 1948 have included research, development, and testing of liquid-propelled rocket engines and associated components (pumps, valves, etc.) (Science Applications International Corporation [SAIC], 1994). Liquid-propellant rocket engine testing activities have been conducted at six major test areas: Bowl, Canyon, Alfa, Bravo, Coca, and Delta. These areas were in operation simultaneously in the late 1950s and early 1960s. The Bowl, Canyon, and Delta test areas were phased out of operation in the late 1960s and 1970s. The Coca test area was shut down in May 1988. The Alfa and Bravo test areas are currently in operation. Engine testing at these areas primarily used petroleum-based compounds as the 'fuel' and liquid oxygen (LOX) as the 'oxidizer.' Solvents were used for cleaning of engine components. Trichloroethene (TCE) was the primary solvent used for cleaning purposes.

In addition to the primary facility operation for testing liquid-propelled rocket engines, the SSFL was used for research, development, and testing of water jet pumps, lasers, liquid metal heat exchanger components, nuclear energy research, and related technologies. Solid propellants, including perchlorate compounds, were primarily used, stored, or tested at two locations within the SSFL, the Building 359 and the Happy Valley sites. In total, these two sites cover only about 12 acres of the total 2,850 acres of the SSFL (Figure 1).

The SSFL conducts comprehensive environmental programs under the jurisdiction of several regulatory agencies. The environmental program at the SSFL pertinent to perchlorate

characterization is RCRA. The RCRA-related activities at the SSFL are regulated by the DTSC. RCRA Corrective Action includes the RCRA facility assessment (RFA), the RFI, corrective measures study (CMS), and corrective measures implementation (CMI) phases. The RCRA program at the SSFL is currently in the RFI phase and includes perchlorate as a chemical of potential concern. This program also includes the authority to implement interim measures cleanup actions when and where appropriate. Surface water discharges from the SSFL have been regulated by the Los Angeles Regional Water Quality Control Board (RWQCB) since 1958, and subject to a permit governed under the National Pollutant and Discharge Elimination System (NPDES) issued by this agency beginning in 1984. Surface water discharges from the site are routinely monitored at eight outfall locations shown on Figure 1.

2.0 BACKGROUND INFORMATION ON PERCHLORATE AT AND NEAR THE SSFL

As noted earlier in Section 1.0, DTSC has requested an RFI work plan for investigating the potential off-site migration of perchlorate from the SSFL. This section of the work plan provides background summaries of the findings presented in the Perchlorate Report (MWH, 2003a) and the results of perchlorate sampling conducted at and near the SSFL from January through May 2003. This background information is used to identify areas at the SSFL that require additional investigation for the potential off-site migration of perchlorate.

2.1 OVERVIEW OF FINDINGS PRESENTED IN PERCHLORATE REPORT

It was stated in the Perchlorate Report (MWH, 2003a) that the amount of soil, surface water, groundwater and spring/seep sampling that had been performed at and near the SSFL adequately identified and delineated the primary impacts at the SSFL except in two areas, the Happy Valley drainage and at the Thermal Treatment Facility (TTF). It was also stated in the report that sampling for perchlorate would be conducted at RFI sites to refine potential clean-up areas or potential future risks to on-site receptors.

2.2 PERCHLORATE SAMPLING FROM JANUARY THROUGH MAY 2003

Significant additional data have been collected since the Perchlorate Report was issued in February of 2003. The additional data that have been collected are:

- For evaluating the potential transport of perchlorate and other constituents of concern (COCs) by periodically collecting and analyzing samples from existing monitoring systems,
- For refining the areas targeted for interim measures at the Building 359 and Happy Valley RFI sites,
- For determining the magnitude of potential perchlorate impacts at the TTF, and
- For confirming previously identified sources at the Compound A RFI site and the Former Sodium Disposal Facility.

The on-going monitoring systems that yielded additional data on the occurrence and distribution of perchlorate at and near the SSFL include the NPDES surface water monitoring program and groundwater monitoring for compliance with the RCRA corrective action and post-closure permit programs. A summary of the perchlorate monitoring results for each program from January through May of 2003 is presented in Table 1. A brief discussion of the results of the sampling events that have occurred is provided in the following sections.

2.2.1 Perchlorate Results from Surface Water Monitoring

As shown in Table 2, the data from the NPDES monitoring program continues to demonstrate that perchlorate is not present in surface water leaving the SSFL at concentrations above the reporting limit at seven of the eight outfalls monitored as required by the NPDES permit. At the eighth outfall (Happy Valley-1 or HV-1), perchlorate was detected in surface water during three of four sampling events conducted between January 1 and May 30, 2003 at an average concentration of about 0.007 milligrams per liter (mg/L) and was not detected during the fourth sampling event (MWH, 2003c).

2.2.2 Perchlorate Results from Groundwater Monitoring

Perchlorate results from the first and second quarter 2003 groundwater monitoring program (Haley & Aldrich, 2003a, 2003b) continue to demonstrate that perchlorate has not been transported very far from the source areas (i.e., within hundreds to a few thousands of feet). Perchlorate continues to be detected in groundwater at the Happy Valley, Building 359, Former Sodium Disposal Facility (FSDF) and Compound A RFI Sites, consistent with the current understanding of perchlorate transport in groundwater beneath source areas.

2.2.3 Perchlorate Results for Interim Measures

Additional perchlorate characterization data have also been collected at the Building 359 and Happy Valley RFI sites (MWH, 2003c). These data have been collected to refine potential areas at these locations that are targeted for interim measures. The Interim Measures Work Plan also specified further characterization work to determine if perchlorate was present in bedrock,

beneath building foundations and/or in drainage sediments that could leach perchlorate to surface water runoff through the Happy Valley drainage and downstream of the Building 359 RFI site. The data collected during the interim measures program will be used to determine if any characterization work beyond that proposed in the Interim Measures Work Plan is warranted along the Happy Valley drainage. Also, it was reported in the Interim Measures Work Plan that a pipe ran beneath the Area I Road that may have conveyed storm water runoff from the northern portion of the Building 359 RFI site. The pipe is believed to have discharged at or near the toe of the Area I landfill into the headwaters of the Northern Drainage. It is possible then, that storm water that may have contained perchlorate from the northern portion of the Building 359 RFI site was discharged into the headwaters of the Northern Drainage.

2.2.4 Perchlorate Results from Sampling at the TTF

Preliminary perchlorate characterization data were also collected by DTSC in March 2003 at the TTF. Boeing collected split samples at each location sampled by DTSC. The preliminary analytical results for perchlorate in both surface water (four locations) and soil leachate samples (seven locations) showed only one detection in surface water at a value of 0.0043 mg/L, which is just slightly over the reporting limit of 0.004 mg/L. Perchlorate was not detected at the seven soil leachate or three other surface water sampling locations. These data confirm the general conclusion reached in the Perchlorate Report (MWH, 2003a) about perchlorate at the TTF, which was that any releases of perchlorate would likely be small.

2.2.5 Off-site Perchlorate Results from Agency Sampling

Both the DTSC and the RWQCB have collected additional samples of surface water, soil leachate and/or groundwater at off-site locations surrounding the SSFL since the Perchlorate Report (MWH, 2003a) was issued. With the possible exception of OS-9, sampling results report no detections of perchlorate to the best of Boeing's knowledge, although Boeing has not been provided and hence has not reviewed the laboratory reports.

2.2.5.1 Chronology of Sampling Events for Perchlorate At OS-9

The remaining piece of new perchlorate data that has been collected since the February 2003 Perchlorate Report is that associated with OS-9. A chronological summary of the sampling results for this location is provided below since these results are cited by the DTSC in its letter to Boeing as the basis for additional perchlorate characterization (DTSC, 2003, see Appendix A).

March 20, 2002 – OS-9 was sampled and analyzed for perchlorate by staff from the DTSC. Analytical laboratory results from the DTSC reported that perchlorate was not detected at a reporting limit of 0.003 mg/L.

February 21, 2003 – OS-9 was sampled and analyzed for perchlorate, along with 4 other wells on the Brandies-Bardin Institute property north of the SSFL. The sampling was performed at the request of the County of Ventura's Public Works Agency. Boeing was made aware of the sampling results via a facsimile from the Los Angeles RWQCB on May 28, 2003. A commercial laboratory (Weck Laboratories, Inc.) initially reported perchlorate in the sample at a concentration of 0.082 mg/L. The laboratory subsequently revised this reported result to ***not detected*** at a reporting limit of 0.004 mg/L in an email transmittal to the RWQCB on July 17, 2003. It was reported that the laboratory mistakenly identified a peak on the chromatogram as perchlorate when it was not perchlorate.

May 30, 2003 – Staff from DTSC sampled and analyzed groundwater from OS-9 for perchlorate. A commercial laboratory (American Scientific, who subsequently subcontracted the work to American Technology Laboratories) reported perchlorate concentrations of 0.14 mg/L from one sample and a concentration of 0.15 mg/L from a duplicate sample.

June 11, 2003 - Staff from DTSC re-sampled and analyzed groundwater from OS-9 for perchlorate. A commercial analytical laboratory (American Scientific, who subsequently subcontracted the work to American Technology Laboratories) reported perchlorate concentrations of 0.036 mg/L and a duplicate result of 0.039 mg/L. Split samples were also collected by DTSC staff on the same date and were sent to DTSC's Hazardous Materials Laboratory in Berkeley, CA. The HML reported that perchlorate was not present in the two

samples at a reporting limit of 0.004 mg/L. Additionally, DTSC staff collected three samples of saturated soil adjacent to the bathtub into which the well discharges. Perchlorate was not detected in these three soil samples above a reporting limit of 0.04 milligrams per kilogram (mg/kg).

Boeing initiated a weekly sampling program for OS-9 on July 2, 2003 because of the inconsistent sampling results described above. The weekly sampling has been performed consistent with that described in a work plan that was submitted to DTSC on July 16, 2003, a copy of which is provided in Appendix B. In accordance with the work plan, samples were collected by Boeing's contractor on the 2nd, 10th, 17th, 24th and 31st of July, and the 7th and 12th of August, 2003 and were analyzed for perchlorate. Perchlorate was not detected in samples collected from OS-9 during these sampling events. A full summary of the sampling events conducted at OS-9 since the beginning of July 2003 is provided in Appendix C.

Furthermore, chemists commissioned by Boeing have reviewed available analytical laboratory data from the May and June 2003 sampling events where perchlorate was reportedly detected in samples from OS-9. This review has cast doubt as to whether perchlorate was actually present in the samples collected during the May and June sampling events. The chemists evaluation of the analytical laboratory results from these sampling events is provided in Appendix D. This analysis, coupled with the weekly sampling results from OS-9 conducted over the last seven weeks call in to question whether perchlorate is or has ever been truly present in samples collected from OS-9.

2.3 SUMMARY OF SSFL BACKGROUND INFORMATION ON PERCHLORATE

In summary, additional samples of various environmental media have been collected and analyzed for perchlorate both on- and off-site of the SSFL since the sampling described in the Perchlorate Report (MWH, 2003a). Media that have been sampled to characterize the occurrence and concentration of perchlorate associated with the potential transport pathways include:

- Stormwater for NPDES sampling and monitoring requirements and for source characterization to evaluate the surface water transport pathway,
- Groundwater for plume identification and monitoring to evaluate the groundwater transport and surface water-to-groundwater transport pathways, and
- Soil, soil leachate and drainage sediment leachate for source and transport characterization.

These data, as described previously in this section, indicate that additional characterization is required in the Happy Valley drainage and in the Northern Drainage. Characterization of the Happy Valley drainage has already been proposed in the Interim Measures Work Plan (MWH, 2003c). The objective of this work plan will be to:

1. Confirm that perchlorate is absent in OS-9, and

2. Characterize the potential impacts of perchlorate, if any, along the Northern Drainage of the SSFL potentially associated with historic operations at the Building 359 RFI site. The rationale for focusing the scope of this work plan to the Northern Drainage is based on historic and recent characterization results and the SSFL's on-going monitoring results for perchlorate.

3.0 BACKGROUND INFORMATION AND PERCHLORATE SAMPLING RESULTS ALONG THE NORTHERN DRAINAGE

Available background information and perchlorate sampling results were compiled to assist in the development of a scope of work to characterize the nature and extent of potential perchlorate impacts to the Northern Drainage from the Building 359 RFI site. This section of the work plan discusses the background information and the available perchlorate sampling results.

3.1 CATCHMENT AREA AND SLOPE OF DRAINAGE

The Northern Drainage of the SSFL collects storm water runoff from a catchment area of approximately 780 acres. The drainage and catchment area are shown on Figure 2. Plate 1 depicts the drainage from its headwaters at the SSFL to the location of OS-9 and has been stationed for ease of reference. A profile of the drainage is also shown on Plate 1. As can be seen on the profile, the drainage exhibits five general changes in slope from the Area I Landfill at the SSFL to OS-9. The slope of the drainage between stations 10+00 and 18+00 is about 0.12 feet per foot (ft/ft). Between stations 18+00 and 83+00, the drainage flattens to a slope of about 0.04 ft/ft. The drainage then steepens to a slope of 0.3 ft/ft from station 83+00 to station 95+00 and the drainage becomes less steep with a slope of 0.075 ft/ft to station 105+00. From station 105+00 to 148+00, the slope of the drainage flattens to 0.03 ft/ft.

3.2 RFI SITES WITHIN CATCHMENT AREA

SSFL RFI sites that lie within the catchment area of this drainage include the following:

- The former B-1 Test Area (Solid Waste Management Unit (SWMU) 4.1),
- The Instrument and Equipment Laboratories (SWMUs 4.3 and 4.4),
- The former Liquid Oxygen Plant (owned by the National Aeronautics and Space Administration, SWMU 4.5),
- The Area I and Area II Landfills (SWMUs 4.2 and 5.1, respectively),
- The former Incinerator Ash Pile (SWMU 5.6),

- The eastern portion of the Expendable Launch Vehicle site (SWMU 5.2), and
- The Area II sewage treatment plant (Area II Area of Concern).

Also, as mentioned in Section 2.2.3, storm water runoff from the northern portion of the Building 359 Area likely drained via a pipe beneath the Area I Road and discharged to the Northern Drainage even though the Building 359 Area lies wholly in a different surface water catchment area. The catchment of the Northern Drainage also includes the southern portions of the Santa Monica Mountains Conservancy property that lies to the north of the SSFL property boundary as shown on Plate 1.

Available perchlorate sampling data from the characterization of the various facilities identified above was previously reported (MWH, 2003a). The Area I and II landfills have not yet been characterized but are proposed for characterization according to the work plan submitted to the DTSC (MWH, 2003d). Hence, the potential for these two landfills to act as perchlorate sources to the Northern Drainage will be evaluated once the work plan is approved by the DTSC. However, it is expected that if the landfills are perchlorate sources at all, that they would be small because the existing data as presented in Sections 2.2 above and 3.1 below do not show perchlorate to be present in the environmental media that have historically been sampled at locations proximal to the landfills.

3.3 GEOLOGIC FEATURES ALONG NORTHERN DRAINAGE

The Northern Drainage runs either along or across a number of geologic features that have been identified at the SSFL. From the pipe that ran beneath the Area I Road (station 11+00), a southern reach of the Northern Drainage ran across the Area I Landfill and crossed over the Shear Zone at station 13+00. This southern tributary tied into the primary reach of the Northern Drainage along the North Fault at station 18+00. The Northern Drainage then basically flows westward along strike of the North Fault for about 5,600 feet from station 18+00 to approximately station 74+00. Two finer-grained stratigraphic members intersect the North Fault along this reach of the drainage. Shale 2, one of the finer-grained members, intersects the North Fault between stations 43+00 and 54+00. It should be noted that the North Fault off-sets Shale 2

between the north and south sides of the fault. The SPA Member, which is the second finer-grained member, intersects the North Fault approximately between stations 56+00 and 57+00. At station 74+00, the Northern Drainage flows northward with slight jogs to the west between stations 90+00 and 100+00 and between stations 130+00 and 150+00. Along this reach of the drainage, the finer-grained ELV Member intersects the drainage between stations 80+00 and 82+00. Further to the north, Shale 3 intersects the drainage just below station 115+00. The geologic contact between Chatsworth formation and the Simi Conglomerate formation intersects the drainage at station 115+00.

3.4 OTHER PHYSICAL FEATURES

Other physical features along the drainage include:

- Two dams have been constructed along the Northern Drainage on the Brandeis-Bardin Institute property. One dam was constructed in about 1965 at station 106+00. The other dam was constructed sometime after 1952 at about station 113+00.
- A section of the drainage between stations 84+00 and 122+00 appears to be an area of groundwater discharge (i.e., the drainage appears to be a gaining stream) as evidenced by a number of groundwater seeps, springs and surface pools.

3.5 EASTERN DRAINAGE TRIBUTARY

Another tributary contributes storm water runoff to the Northern Drainage at station 130+00. This tributary lies north of the SSFL property boundary and its headwaters are sourced to the east of Black Canyon Road. This tributary to the Northern Drainage (labeled East Drainage on Plate 1) collects and conveys storm water runoff from residential properties located east of Black Canyon Road, from portions of the Santa Monica Mountains Conservancy property and from portions of the Brandies-Bardin Institute.

3.6 PERCHLORATE SAMPLING RESULTS ALONG THE NORTHERN DRAINAGE

Surface water, groundwater and spring/seep samples have been collected and analyzed for the occurrence and concentration of perchlorate since 1999. Three surface water samples have been

collected at three distinct locations along the Northern Drainage. Sample locations and results are shown on Plate 1. One of the surface water samples was collected near the Area I landfill in February of 2001 (station 13+00). Perchlorate was not detected in this sample at a reporting limit of 0.003 mg/L. A second surface water sample was also collected in February of 2003 north and down stream of the Area II landfill (station 71+00). Perchlorate was not detected in this sample at a reporting limit of 0.004 mg/L. The third surface water sample was collected further down the drainage in 1999 as part of the NPDES sampling program (station 82+00). Perchlorate was not detected in this sample at a reporting limit of 0.004 mg/L.

Groundwater samples have been collected and analyzed for perchlorate from four wells located along and near the Northern Drainage. Well WS-4A was sampled on five different occasions between November 1997 and November 2000 (station 37+00). Perchlorate was not detected in the samples collected from this well, at reporting limits ranging from 0.001 mg/L to 0.004 mg/L. Well RD-52B was sampled on five different occasions between February 1999 and February 2003 (station 54+00). Perchlorate was not detected in the samples collected from this well, at reporting limits ranging from 0.00043 mg/L to 0.004 mg/L. Well RD-52C was sampled on four different occasions between November 1997 and November 2000 (station 53+00). Perchlorate was not detected in the samples collected from this well, at reporting limits ranging from 0.001 mg/L to 0.004 mg/L. OS-9 (station 147+00) sampling results were previously presented in Section 2.2.5.1.

Prior to July 2003, samples have been collected and analyzed for perchlorate at two different springs/seeps. A sample was collected from spring/seep location S-17 in June of 2002 (station 94+00) and perchlorate was not detected at a reporting limit of 0.001 mg/L. Four samples have been collected from OS-8 (station 100+00) between February of 1999 and January of 2003. Perchlorate was not detected in the four samples collected from this spring/seep, at reporting limits ranging from 0.00043 mg/L to 0.004 mg/L.

Staff from the DTSC also reportedly collected a soil sample and produced a field leachate at a location noted as East Canyon-1 (station 122+00) in May of 2002 and perchlorate was not detected at a reporting limit of 0.003 mg/L.

3.7 OTHER WATER CHEMISTRY RESULTS

Samples from groundwater and springs/seeps have also been collected at locations along the Northern Drainage and analyzed for background water quality parameters. Samples have been analyzed for general minerals and total dissolved solids (TDS) from eight groundwater wells and two springs/seeps. Stiff diagrams depicting the cation and anion results for these locations are shown on Plate 1. As noted by the shape of the stiff diagrams, wells and springs that are positioned in the Chatsworth formation are a calcium-bicarbonate type groundwater. Wells and springs positioned in the Simi Conglomerate formation or near the contact with the Chatsworth formation are a sodium-bicarbonate type groundwater. These data indicate that groundwater within these two formations are hydraulically distinct.

3.8 SUMMARY OF DATA ANALYSIS

In summary, samples of surface water, groundwater, spring/seep and soil leachate that have been collected along the Northern Drainage and analyzed for perchlorate showed none to be present. Additionally, general minerals data show that Chatsworth Formation groundwater underlying the SSFL is different from groundwater in the Simi Conglomerate formation.

4.0 DATA NEEDS AND POTENTIAL TRANSPORT PATHWAY ANALYSIS

An independent assessment of the data needed to characterize the potential for a historical perchlorate release from the Building 359 RFI site to the Northern Drainage was made. This assessment indicated that the following data were needed to complete this characterization:

1. Occurrence and concentration of perchlorate and background water quality indicators in groundwater and at seeps/springs and surface water pools along the Northern Drainage.
2. Occurrence and concentration of perchlorate in drainage sediments in the Northern Drainage and its tributaries that are located within the SSFL property boundary.
3. Occurrence and concentration of perchlorate in soils and materials in the Area I and II landfills.
4. Occurrence and concentration of perchlorate in weathered bedrock within the Northern Drainage.
5. Geologic and hydrogeologic conditions along the Northern Drainage of the SSFL.
6. Surface water hydrology along the Northern Drainage.
7. Direction of groundwater flow from the Building 359 RFI site.

Currently available data from items 1, 5 and 7 were reviewed to establish the appropriate focus for this work plan. These data indicate that the primary potential transport mechanism for perchlorate to have possibly been transported from the Building 359 RFI site to the Northern Drainage is by surface water flow. For this transport mechanism to be valid, it is expected that such discharges from surface water to the subsurface would occur along the drainage with the highest concentrations closest to the Building 359 RFI site. This concept is the fundamental design premise for this work plan and is conceptually depicted in Figure 3. Additionally, the potential transport of perchlorate from either the Area I or Area II landfills is another possibility that will be explored upon implementation of the work plan for these two locations (MWH, 2003d, pending review and approval from the DTSC). The conceptual transport mechanism from the landfills would be via leachate production and surface water flow to the Northern Drainage.

The groundwater transport pathway from the source areas in groundwater at the Building 359 Area and from Happy Valley, the other primary perchlorate use area at the SSFL, was considered during this analysis. This transport pathway is considered incomplete for the following reasons:

- Extraction wells WS-5, WS-6 and RD-1, which are located near the two primary use areas for perchlorate at the SSFL (i.e., the Building 359 and Happy Valley RFI sites), induce local hydraulic gradients that would capture Chatsworth formation groundwater impacted by perchlorate at these locations. The general effect of groundwater extraction at WS-5 and WS-6 was presented in the Perchlorate Report (MWH, 2003a).

- Results of one-dimensional single-fracture and two-dimensional fracture-network transport simulations illustrate that, although the rates of groundwater flow in the fractured Chatsworth formation may be very high, the transport rate of perchlorate in the Chatsworth formation is orders of magnitude slower. The slower transport rate is the result of retardation caused by molecular diffusion into the rock matrix.

- Available groundwater sampling results presented in the Perchlorate Report (MWH, 2003a) and the locations of the primary perchlorate use areas at the SSFL (i.e., Building 359 and Happy Valley) show that the site monitoring data are consistent with the slow transport of perchlorate in Chatsworth formation groundwater. Perchlorate is detected in wells proximal to the release locations and bounded by wells with samples showing no detections of perchlorate. These results show the transport distances to be only 100s to a few 1000s of feet from where it was released.

However, work will be proposed as requested by DTSC to confirm that this pathway is incomplete and is described in Section 5.0.

The potential for the transport of perchlorate by possible perchlorate releases to the atmosphere followed by deposition by rain-out was also considered. However, the distribution pattern of wells where perchlorate has been detected is inconsistent with this potential release mechanism (see Plate 4-11 of the Perchlorate Report). Hence, no specific scope of work will be proposed in Section 5.0 to evaluate this potential transport pathway.

5.0 SCOPE OF WORK

The scope of work proposed in this work plan considers:

- The data, information and approaches presented in the previous sections,
- The specific requirements in DTSC's June 23, 2003 letter requesting additional characterization of perchlorate at the SSFL (see Appendix A), and
- Existing work plans that have previously been prepared for conducting similar work at the SSFL.

Table 3 summarizes requested elements for perchlorate characterization as outlined by DTSC in the June 23, 2003 letter, the work that is proposed to be performed to comply with the request and a listing of existing applicable work plans.

Perchlorate characterization along the Northern Drainage from the Building 359 RFI site will include the following tasks:

1 – Sample and analyze drainage sediments
2 – Sample and analyze groundwater
3 – Sample and analyze surface water
4 – Install additional groundwater monitoring wells
5 – Test the aquifer(s)
6 - Evaluate geology, hydrogeology and surface water hydrology
7 - Perform a groundwater corrective measures study

Additional descriptions of the work to be performed for these tasks are outlined below.

5.1 SAMPLE AND ANALYZE DRAINAGE SEDIMENTS

Sediment samples have been collected from surficial and deeper sediments within the active channel of the Northern Drainage. Boeing obtained permission from off-site property owners prior to collecting any off-site samples. The objective of this sampling program was to evaluate

the potential surface water transport of perchlorate from the Building 359 RFI site and the Area I and II landfills. Sediment samples were collected using the guidelines presented below. Sample locations are shown on Plate 2.

The lateral spacing along the drainage at or near RFI sites generally ranged from 50 to 125 feet. Sediment samples were collected near the Area I and Area II landfills at the locations presented in the landfills investigation work plan that was recently submitted to DTSC (MWH, 2003d). The lateral spacing of sediment samples within the drainage increased with distance from the RFI sites. A lateral spacing ranging from 250 feet to 500 feet was used within the SSFL. Off-site to the north of the SSFL, the lateral spacing of sediment samples increased and ranged from 500 feet to 1000 feet. The maximum lateral distance between sample locations did not exceed 1000 feet.

Samples were collected at various depths and across the width of the drainage as outlined below and diagrammatically depicted in Plate 2. Samples were collected at depths between the surface and ½ inch below the surface (designated as sample S01) and at six inches above the bedrock (designated as sample S03). At approximately 10 percent of the sample locations, an additional sediment sample was collected between ½ inch and 4 inches below the surface (designated as sample S02). Additional samples of this type were collected in areas with thin sediment deposits that precluded collecting S03 samples.

Additional sample locations were added along the drainage if salt deposits were noted. Similarly, if salt deposits were observed in the bank(s) of the drainage, additional samples were also collected (designated as sample S04). These samples were in addition to the sample intervals discussed in the previous paragraphs and targeted the salt-bearing unit only.

At representative locations within the drainage where thicker sediment deposits were present, over-bank samples (designated as sample S05) and deeper samples were collected at approximately 6” depth intervals to just above bedrock (designated as samples S06, S07, etc.).

Leachates were produced from the majority of the samples collected using an enhanced leachate protocol as described below. EPA Method 314.0 was used to analyze the leachates for perchlorate. Recently, a enhanced leachate procedure was developed based on information that indicates very near-surface sediments concentrate perchlorate in areas with continuing sources. The enhanced leachate procedure was recently used to sample in previously identified areas with perchlorate impacts at the Happy Valley and Building 359 RFI sites. Side-by-side comparison samples were collected to allow for a comparison to be made between the 'original' and 'enhanced' methodologies. The enhanced procedure uses standardized sample and water amounts, and targets the uppermost sediments at a location (1/2- and 4-inches of sediment) or sediments near salt incrustations. The original leachate method does not standardize sample or water amounts (except in the most general sense of using 4 to 6 sampling sleeves), and targets the upper 6-inches of sediment from the locations being sampled. At these side-by-side comparison locations, the enhanced leachate procedure detected higher concentrations of perchlorate in the uppermost ½-inch of sediment than the 'original' method detected in sediments collected between 0 and 6 inches. It is believed this result occurred because perchlorate is a salt that wicks to the sediment surface as water evaporates. Additional leachate samples were also produced from samples collected at regular intervals using the original methodology developed between MWH and DTSC to compare results between the two methods. The additional leachates (S99 sample identification) were created from sediment samples collected from the surface to 6 inches below the surface at a maximum lateral distance of 1000 feet. In areas of thicker sediment deposits, vertical composites (S99) were also prepared using the original methodology. Leachates from these samples were prepared using the 'original' leachate sampling procedures (see below).

The following guidelines were used to prepare leachates from the sediment samples collected:

- Leachate samples were prepared from all surface and salt deposit samples (S01 and S04).
- Leachate samples were prepared from all upper channel sediments (S02), assuming 10 percent of the locations are sampled in this manner.
- Leachate samples were prepared from above-bedrock samples (S03) at a spacing of no more than 1000 feet. This spacing was decreased near RFI sites or in areas of thick sediment accumulation.

- Leachate samples were prepared from overbank, above bedrock, and at 2-foot intervals in the deeper sediment accumulation areas within the drainage (S05, and S06, etc.). The sediment samples collected from the intervening 6-inch intervals were retained for further analysis if necessary.

- Finally, if water was encountered in any sampling location in the drainage, or in the bottom of the auger boring, then water samples were also collected using a disposable bailer or syringe device.

Sediment or soil samples consisting of sediment or soil matrix were also collected at leachate sampling locations. Locations of these samples depended on the leachate sampling results. At a minimum, at least one sediment sample was collected downstream of every RFI site (typically the one closest to the RFI site). However, two sediment/soil matrix samples were collected downstream of the Area I and Area II landfills.

5.2 SAMPLE AND ANALYZE GROUNDWATER

Groundwater samples will be collected and analyzed for perchlorate and general minerals from both existing wells and springs/seeps and from new wells to be installed as outlined in Section 5.4. The objective of this sampling program is to evaluate the potential groundwater transport of perchlorate from the Building 359 RFI site across geologic features and to evaluate the potential surface water transport pathway along the Northern Drainage. Certain wells located within the SSFL and all off-site wells currently within the site-wide groundwater monitoring program will be sampled and analyzed for perchlorate and general minerals quarterly. Boeing will obtain permission from any necessary off-site property owners prior to collecting off-site samples.

On-site wells to be sampled are identified in the table below and their locations are shown on Plate 2.

Location and Well Type		Wells to be Sampled for Perchlorate and General Minerals	Frequency
On-site	Near-surface groundwater	PZ-062 and four new piezometers to be installed as outlined in Section 5.4	Whenever saturated or quarterly if continually saturated for first year, annually thereafter
	Chatsworth monitoring	RD-37, RD-45A, RD-45B, RD-45C, RD-51A, RD-51B, RD-51C, RD-52A, RD-52B, RD-52C, and RD-70	Quarterly for the first year, annually thereafter
	Former water supply	WS-4A, WS-9B, WS-12, WS-13 and WS-14	Quarterly for one year[1]

Where applicable, existing work plans as shown on Table 3 that contain details about sampling and analysis procedures including the appropriate quality control and quality assurance requirements will be used during the sampling events.

Samples from former water supply wells WS-12, WS-13 and WS-14 will be collected from discrete locations that will be chosen based on the results of hydrophysical logs. The objective of this task is to determine of perchlorate and other COCs are present in these water supply wells and, if so, to obtain an understanding of their vertical distribution. These data will also be useful in evaluating both the potential surface water transport pathway along the Northern Drainage and the potential groundwater transport pathway from the source in groundwater at the Building 359 RFI site. If available, the United States Geologic Survey (USGS) will collaborate with the University of Waterloo and MWH to collect fluid temperature, fluid resistivity and either or both electromagnetic and heat-pulse flow meter logs. Similar measurements were previously made by the USGS in three boreholes at the SSFL (USGS, 2002). Descriptions of the methods to be used for hydrophysical logging are as follows:

- Fluid-resistivity logging will record the electrical resistivity of the water in the former water supply wells. The electrical resistivity of the water is related to its dissolved-solids concentration. Fluid-resistivity logs will be collected under ambient and pumped

[1] The frequency and location of samples to be collected from former water supply wells WS-12, WS-13 and WS-14 will be dependent upon the results of hydrophysical logging.

conditions. The fluid-resistivity logs will be combined with the temperature and flowmeter logs to identify flow zones and to determine the relative dissolved-solids concentration of their contained water.

- Temperature logging will record the temperature of the water in the water supply wells. In wells with no vertical flow, the temperature of the water within the well generally increases with depth as a function of the geothermal gradient in the surrounding rocks. Temperature gradients less than the geothermal gradient may indicate intervals with vertical flow. Temperature logs will be used with the fluid-resistivity and electromagnetic or heat-pulse flowmeter logs to identify flow zones under ambient and pumped conditions.

- Electromagnetic flowmeter logging will record the direction and rate of vertical flow in the water supply wells. The flow of water (an electrical conductor) through an induced magnetic field generates a voltage gradient that according to Faraday's Law, is proportional to its velocity. Stationary flow measurements will be made under ambient conditions and both trolling and stationary measurements will be made under pumped conditions. The electromagnetic-flowmeter logs will be used in conjunction with the fluid-resistivity and temperature logs to identify flow zones, commonly composed of multiple fractures and their relative hydraulic head, flow contribution and dissolved-solids concentration.

Staff from the USGS will interpret the hydrophysical logs and recommend discrete intervals for water quality sampling from the water supply wells. The data produced from these logs at these water supply wells is expected to provide information useful to the site-wide characterization of the Chatsworth formation. Sampling of these wells will be performed using a canister sampling device to collect discrete samples that will be submitted for perchlorate analysis, general minerals, volatile organic compounds (VOCs) and other constituents as appropriate. Certain elements of the canister sampler will be decontaminated between sampling events according to the procedures identified in the Site-Wide Sampling and Analysis Plan (GRC, 1995a).

Samples from springs/seeps located along the Northern Drainage will be collected and analyzed for perchlorate twice annually for the first year and will follow the procedures outlined in the Spring and Seep Sampling Work Plan (MWH, 2002a). The objective of the spring/seep sampling program is to confirm that perchlorate releases to groundwater remain local to their respective release location. Sampling locations are shown on Plate 2. Additionally, other springs and seeps currently in the site-wide groundwater monitoring program will also be sampled and analyzed for perchlorate. Twice per year sampling is proposed for springs/seeps

because of their transient occurrence. Spring/seep sampling events will be conducted once during the late spring and again in the early fall (assuming spring/seep discharges are still occurring). Spring/seep samples will not be collected during winter and early spring because surface water flows along the drainage dilute and/or submerge the springs/seeps during these periods. Samples will be analyzed for perchlorate, general minerals, including total dissolved solids and stable oxygen and hydrogen isotopes. Should perchlorate be detected in a spring/seep sample, a sample of the alluvium/colluvium and or bedrock adjacent to the spring/seep will also be collected and submitted for perchlorate analysis.

5.2.1 OS-9 Sampling and Analysis

Groundwater samples will be collected from OS-9 weekly for two months starting in July 2003, monthly for 10 months and quarterly thereafter. All samples will be analyzed for perchlorate. Samples will be analyzed for general minerals and stable oxygen and hydrogen isotopes monthly for the first year and quarterly thereafter. The sampling program is described in further detail in Appendix B. The objective of this sampling program is to confirm that perchlorate is absent in groundwater flowing from OS-9.

5.3 SAMPLE AND ANALYZE SURFACE WATER

Both one-time and periodic surface water samples will be collected from the Northern Drainage and analyzed for perchlorate. The objective of these samples is to evaluate potential surface water transport of perchlorate from the Building 359 RFI site and the Area I and II landfills. The one-time sampling event occurred in July 2003 from surface water pools that were identified during an inspection of the drainage. Locations that were sampled are shown on Plate 2. Samples were analyzed for general minerals, including total dissolved solids, and stable oxygen and hydrogen isotopes to determine if the pooled water was surface water or groundwater.

Periodic surface water samples will also be collected and analyzed for perchlorate during the rainy season in accordance with the requirements specified by the Los Angeles RWQCB.

5.4 INSTALL ADDITIONAL GROUNDWATER MONITORING WELLS

Four additional near-surface groundwater monitoring wells will be installed along the Northern Drainage. The objective of these wells is to determine if near-surface groundwater is present near the Northern Drainage down-slope from the Area I and II landfills and, if so, to determine if it has been impacted by perchlorate. The wells will be installed north of the Area I and Area II landfills at the locations proposed in the Landfills Investigation Work Plan (MWH, 2003d). The proposed locations for these wells are shown on Plate 2. The wells will be drilled and installed according to the procedures specified in the Shallow Zone Groundwater Investigation Work Plan (Ogden, 2000c), which has been approved by the DTSC.

One enhancement will be made to the drilling and sample collection procedures specified in the Shallow Zone Groundwater Investigation Work Plan. The enhancement will consist of sampling the weathered bedrock at the western most well to be installed north of the Area II landfill (near station 70+00 on Plate 2). The objective of sampling the weathered bedrock is to evaluate potential surface water transport of perchlorate along the Northern Drainage. A continuous core of the weathered bedrock will be collected using a wireline coring device. Weathered bedrock samples will be collected from the core at approximately one-foot intervals from its first occurrence in the borehole to the unweathered bedrock contact. The rock samples will be collected and crushed according to the procedures outlined in the Chatsworth Formation Work Plan (Montgomery Watson, 2000b). The crushed rock samples will be placed into glass jars containing appropriate amounts of de-ionized water. The samples will be shaken for a defined period to dissolve any residual perchlorate that may be present in the crushed rock and aliquots of the water will be extracted from the sample container and analyzed for perchlorate.

Additional Chatsworth formation monitoring wells are not being proposed at this time. The current understanding of the groundwater flow system from the source areas impacted by perchlorate at the SSFL indicates that perchlorate is effectively contained due to faults and fine-grained stratigraphic members that are aquitards that inhibit groundwater flow. Additional work will be performed as outlined in Section 5.5 to confirm the aquitard characteristics of the Shear Zone. The Shear Zone is the primary geologic feature that substantially isolates the potential

northwesterly transport of perchlorate impacted groundwater at the Building 359 and Happy Valley RFI sites. Additionally, the data obtained from the hydrophysical logging and subsequent discrete-interval sampling of water supply wells WS-12, WS-13 and WS-14 will provide data to confirm or refute the lack of northwesterly transport of perchlorate-impacted groundwater from the east side of the Shear Zone to the west side. However, additional Chatsworth formation wells will be considered if sampling results from the water supply wells are inconclusive or if results indicate the presence of perchlorate. The locations to be selected for the installation of additional Chatsworth formation wells will be dependent upon completing a three-dimensional groundwater flow model.

5.5 TEST THE AQUIFER(S)

An aquifer test will be performed to evaluate the potential transport of perchlorate in groundwater from the Building 359 RFI site toward the northwest. The aquifer test will be performed by extracting groundwater from corehole C-1 and monitoring pressure responses in a number of surrounding monitoring wells. Details of the proposed aquifer test were previously described in a transmittal to the DTSC (Boeing, 2003). However, in addition to monitoring water level responses in the wells proposed in the aquifer test work plan, a pressure transducer will be installed in well WS-14 to monitor for potential water level changes in this well. WS-14 is located on the opposite side of the Shear Zone (i.e., on the west side) from the selected extraction well C-1.

If necessary, an aquifer test can also be performed by using WS-14 as the extraction well. However, the use of WS-14 as an extraction well will be reserved as a contingency. The results from the C-1 aquifer test along with the USGS hydrophysical logging and subsequent discrete-interval sampling of WS-12, WS-13 and WS-14 will be reviewed and considered prior to determining the need for an additional aquifer test using WS-14 as an extraction well. The need for the aquifer test will be determined in consultation with the DTSC.

5.6 EVALUATE GEOLOGY, HYDROGEOLOGY AND SURFACE WATER HYDROLOGY

The geology, hydrogeology and surface water hydrology along the Northern Drainage from the SSFL to the vicinity of OS-9 will be evaluated. The geology will be evaluated by field mapping and the inspection of aerial photos. Photographs of notable geologic features identified during the field mapping will also be taken and incorporated as part of the geologic characterization. Where possible, correlations of the lithology at depth will be constructed from borehole geophysical logs that will be obtained as part of the Chatsworth Formation Work Plan (Montgomery Watson, 2000b). Advanced borehole geophysical logs have been obtained from WS-14 and will be collected from WS-12 in the near future (see MWH, 2002b for a description of the borehole geophysical logs that are produced for this work). The objective of the geologic characterization will be to verify the existing geologic framework and to determine the stratigraphy of the Simi Conglomerate and its potential effect on groundwater occurrence and flow.

A summary of the hydrogeology will also be prepared for the groundwater along the Northern Drainage. Hydrogeologic data presented in Appendix B of the Conceptual Site Model Technical Memorandum (Montgomery Watson, 2000a) will be summarized and coupled with the hydrogeologic data that will be collected as described in this work plan. Data on depth to groundwater, groundwater elevations, well responses to pumping, hydraulic conductivity, groundwater flow rates and directions and intra-well flow zones, where applicable, will be presented and discussed.

Surface water flows along the Northern Drainage will also be characterized from the head waters at the SSFL. Surface water flows along a tributary drainage that lies to the north of the SSFL (i.e., the Eastern Drainage, see Plate 1) will also be characterized as this drainage connects with the Northern Drainage north of the SSFL. Surface water flow rates will be estimated using appropriate methods and or models for various precipitation events. The objective of this analysis is to obtain a general assessment of the surface water flows along the Northern Drainage to assist in assessing potential surface water transport of perchlorate.

5.7 PERFORM A GROUNDWATER CORRECTIVE MEASURES STUDY

A corrective measures study on the groundwater underlying the SSFL will be initiated by preparing a corrective measures study work plan as specified in the Post-Closure Permit (DTSC, 1995). The corrective measures study work plan will specify how the CMS report will be prepared and will be used to identify and evaluate potential remedial alternatives to address the groundwater impacted by COCs that underlies the SSFL. The corrective measures study work plan will be performed consistent with Attachment E of the Post-Closure Permit and the requirements specified in Section 66264.101 of Title 22 of the California Code of Regulations. The corrective measures study work plan will be submitted within 90 days of DTSC's approval of this work plan.

Although a request has been made by DTSC to assess potential interim measures to reduce or contain perchlorate with the objective of controlling further migration from identified source areas, such actions are unlikely to be useful for the following reasons.

1. Currently available treatment technologies to remove perchlorate from extracted groundwater are well-known and readily implementable if appropriate.

2. Perchlorate is only one of the known constituents dissolved in groundwater at the identified source areas, hence any evaluation of technologies needs to consider all of the COCs.

3. The current understanding of perchlorate occurrence and transport in SSFL groundwater indicates that there is no immediate threat requiring an interim action. Existing interim measures associated with groundwater extraction at WS-5, WS-6 and RD-1 are effective at capturing perchlorate impacted groundwater at the Building 359 and Happy Valley RFI sites as discussed in Section 4.0. Furthermore, molecular diffusion of dissolved perchlorate in groundwater into the sandstone bedrock that comprises the Chatsworth formation is effective in the short term at containing perchlorate-impacted groundwater and in controlling further transport.

4. The time and effort associated with modifying the post-closure permit (DTSC, 1995) to incorporate a unit operation into the existing treatment system(s) to treat perchlorate-impacted groundwater are long and extensive. Consideration of such modifications is inappropriate prior to completing the corrective measures study.

6.0 SCHEDULE AND DELIVERABLES

Portions of the scope of work have been initiated by Boeing because the presence of certain environmental media are transient and subject to variations in the climate. Samples from surface water pools discussed in Section 5.3 were collected in the early and middle portions of July 2003 as these pools evaporate as summer progresses. Similarly, the spring/seep samples that are discussed in Section 5.2 were also collected in July 2003 because their discharge either becomes too small to collect a representative sample or ceases altogether as summer progresses. The sampling program for OS-9 proposed by Boeing in the July 12, 2003 letter (see Appendix B) was also initiated in July and continues as of the date of this work plan. Available results were presented in Section 2.2.5.1 and Appendix C. Finally, sampling of the drainage sediments as outlined in Section 5.1 was also initiated in July to assess whether perchlorate is present in drainage sediments at the locations shown on Plate 2. Analytical results from samples noted above are still pending.

Sampling of the Chatsworth formation, 2 of the 5 water supply and the off-site wells will be initiated within 60 days of DTSC's approval of this work plan. The near-surface piezometers will be sampled within 45 days of installation if saturated and whenever PZ-062 becomes saturated (multiple gauging events conducted at PZ-062 over the last few years have not encountered groundwater). Installation of the four proposed near-surface piezometers will commence within 45 days of DTSC's approval of the Area I and II Landfills Investigation Work Plan (MWH, 2003d). Hydrophysical logging and discrete sampling of water supply wells WS-12, WS-13 and WS-14 will be initiated within 90 days of DTSC's approval of this work plan, assuming the USGS logging and sampling equipment is available for shipment to the SSFL.

The periodic sampling of surface water from the Northern Drainage will be initiated during the rainy season whenever sufficient runoff is generated and at the frequency specified by the Los Angeles RWQCB.

The pumping test at corehole C-1 is expected to be started on August 25, 2003.

Work has been initiated to evaluate the geology and surface water hydrology along the Northern Drainage. It is expected that this work will be substantially complete within 60 days of DTSC's approval of this work plan.

6.1 DELIVERABLES

An RFI site report describing the work performed, analytical laboratory results and other data and interpretations as discussed in Section 5.0 will be prepared and submitted within 180 days of DTSC's approval of this work plan. This report will also identify any additional gaps in the data that might exist and a plan will be prepared that identifies the work that would need to be performed to fill the data gaps.

Available sampling data will be summarized and presented in a perchlorate update report that will be submitted to the DTSC by November 15, 2003. This report will include results of Northern Drainage sampling data and other perchlorate sampling data collected both within the SSFL property boundary and in off-site areas. If made available, the report will also include perchlorate results from samples collected by DTSC, the RWQCB and other agencies as appropriate. Supplemental perchlorate report amendments can also be produced in the future if significant additional data are collected.

Periodic monitoring results from wells and springs/seeps to be sampled as described in this work plan will be included in the quarterly or annual groundwater monitoring reports that are submitted to DTSC on the last day of February, May, August and November of each year.

Finally, as noted in Section 5.7, a corrective measures study work plan for groundwater will be submitted within 90 days of DTSC's approval of this perchlorate characterization work plan.

7.0 SUMMARY

This RFI work plan presents characterization activities to evaluate the potential for off-site migration of perchlorate from the SSFL in response to a DTSC letter dated June 23, 2003 (Appendix A). DTSC has requested the submittal of a work plan describing measures to be taken to investigate the potential migration of perchlorate contamination from the SSFL to off-site areas such as the Brandeis-Bardin Institute property. This RFI work plan presents characterization activities necessary to (1) confirm that perchlorate is absent in OS-9 (Bathtub Well #1), and (2) evaluate the potential migration of perchlorate from the SSFL to off-site areas.

A comprehensive report on the occurrence of perchlorate at and near the SSFL was issued in February 2003 (MWH, 2003a). This report documented the usage of perchlorate at the SSFL, identified source areas, evaluated migration pathways and perchlorate transport and evaluated potential off-site migration of perchlorate from the SSFL. The report also contained conclusions about the occurrence of perchlorate at the SSFL and discussed areas requiring further characterization. Three areas were identified in the report as requiring additional work to evaluate the nature and extent of perchlorate in soil, surface water and/or groundwater: Happy Valley, Building 359 and the TTF.

Two of the areas, the Happy Valley and Building 359 RFI sites, have been the focus of additional characterization work to define areas for treatment under interim measures. Characterization of these two areas continues as outlined in the Interim Measures Work Plan (MWH, 2003c). Preliminary characterization work has also been performed at the third area, the TTF. The data produced from the samples collected at the TTF show negligible impact as only one of the eleven samples contained perchlorate and the concentration detected was slightly above the reporting limit (0.0043 mg/L). This recent data collected from the TTF supports the conclusion presented in the Perchlorate Report. The report concluded that any perchlorate releases at the TTF would likely be small as monitoring results from wells located adjacent to the TTF and from surface water sampling from designated NPDES outfalls did not show perchlorate to be present. Additional perchlorate monitoring data from surface water samples collected since

January 2003 from designated outfalls around the SSFL and from groundwater monitoring well samples also confirm the conclusions presented in the Perchlorate Report.

The initial work completed under the Interim Measures Work Plan for the B359 RFI site discovered a potential migration pathway requiring additional characterization (MWH, 2003c). The potential pathway is surface water transport via a former drainage pipeline leading to the Northern Drainage. As presented in Section 3.0 of the work plan herein, a significant amount of data exists regarding various potential migration pathways from this drainage. Data collected to date within the SSFL and along the Northern Drainage do not currently indicate that off-site migration of perchlorate is occurring north of the SSFL. The data supporting this statement include samples from groundwater monitoring and water supply wells, from springs/seeps and from surface water. Furthermore, as discussed in Section 2.2.5.1 of this work plan, additional groundwater samples collected at OS-9 in July and August 2003 show that perchlorate is absent. An evaluation of OS-9 perchlorate data collected on May 30 and June 11, 2003 indicate results are inconsistent and that additional validation is necessary before these data can be used.

The scope of work presented in the work plan herein is summarized on Figure 4 and includes the following:

- Collecting groundwater samples from OS-9 weekly for two weeks, monthly for 10 months and quarterly thereafter. All samples will be analyzed for perchlorate. Samples will be analyzed for general minerals and stable oxygen and hydrogen isotopes monthly for the first year and quarterly thereafter.

- Collecting sediment samples from more than 60 locations within and along the Northern Drainage and laboratory analysis of leachates from approximately 100 samples collected at these locations for the occurrence and concentration of perchlorate.

- Collecting groundwater samples from five near-surface, 11 Chatsworth formation, five former water supply and those off-site wells currently in the site-wide groundwater monitoring program and analyzing the samples for perchlorate and general minerals. Groundwater will be collected from the near-surface, Chatsworth formation, off-site and two of the five water supply wells quarterly for one year and analyzed for perchlorate and general minerals. After the first year of sampling, the sample frequency will become annual. Three of the water supply wells will be hydrophysically logged by the USGS and discrete-interval samples will be collected and submitted for perchlorate and VOC analysis based on the results of the hydrophysical logs.

- Collecting spring/seep samples from six locations along the Northern Drainage and analyzing the samples for perchlorate twice annually. Samples will be collected once during the late spring and again in the late fall. These samples will also be analyzed for general minerals, including total dissolved solids and stable oxygen and hydrogen isotopes. Samples will also be collected from seeps/springs currently in the site-wide groundwater monitoring program and analyzed for perchlorate and general minerals.

- Collecting one-time surface water samples from nine pools that have been identified along the Northern Drainage and analyzing the samples for perchlorate, general minerals and stable oxygen and hydrogen isotopes. When flowing, surface water samples will also be collected along the Northern Drainage as required by the RWQCB and analyzed for perchlorate.

- Installing four additional near-surface groundwater monitoring wells along the Northern Drainage consistent with what has been proposed in the Landfills Investigation Work Plan (MWH, 2003d) and according to the procedures specified in previously submitted and DTSC-approved Shallow Groundwater Investigation Work Plan (Ogden, 2000c). Samples of weathered bedrock will be collected at one-foot intervals during the installation of one well and processed and analyzed for the occurrence and concentration of perchlorate. No Chatsworth formation wells are proposed for installation as part of this work plan because the existing data do not indicate that they are needed.

- Testing the aquifer by performing a pumping test at corehole C-1. As a contingency, an additional aquifer test can be performed using WS-14 as an extraction well. The objective of these aquifer tests is to evaluate the groundwater flow system near the perchlorate source areas at the SSFL and to evaluate the effectiveness of geologic features in the vicinity of extraction wells as aquitards. If the data collected as specified in this work plan indicate a need for a Chatsworth formation well(s), such a well(s) will be installed following the completion of a three-dimensional groundwater flow model.

- Evaluating the geology, hydrogeology and surface water hydrology along the Northern Drainage within the SSFL to the vicinity of OS-9. The geology will be evaluated through field mapping, inspection of aerial photos and correlation of borehole geophysical logs. Existing hydrogeologic data will be combined with the hydrogeology data to be collected as described in this work plan. Surface water flows from various precipitation events will be characterized.

- Performing a groundwater corrective measures study to evaluate possible measures to reduce and/or contain perchlorate and other COCs in impacted groundwater that underlies the SSFL. The corrective measure study will identify and screen potential treatment technologies for perchlorate and other COCs in groundwater and will include both *in situ* and aboveground treatment technologies. The technologies will then be developed into specific alternatives and evaluated with respect to their effectiveness, compliance with applicable laws and regulations, implementability and cost.

A report will be prepared and submitted within 180 days of DTSC's approval of this work plan herein. The report will describe the data collected and an interpretation of results. Plans for collecting any additional data will also be included.

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